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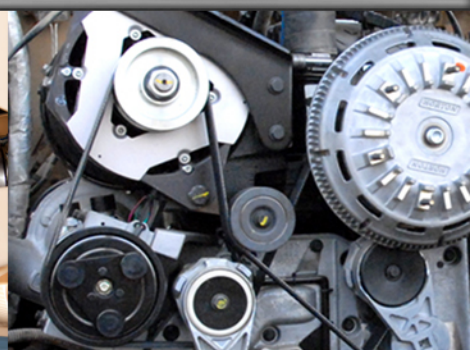
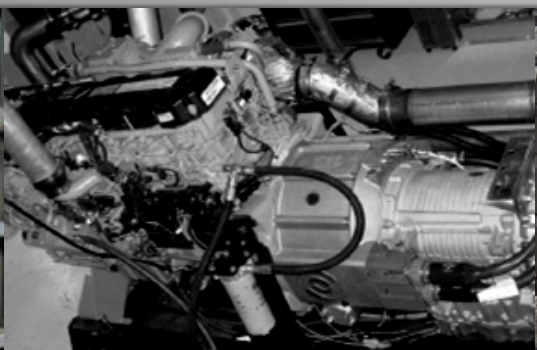


DETC2015-46367

The Effects of Soldier Gear Encumbrance on Restraints in a Frontal Crash Environment

ASME 2015 IDETC/CIE
AVT-7-1 Advances in Military and
Commercial Ground Vehicle
Design

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OUTLINE



- Background
- Goals
- Test Methodology
- Encumbrance Selection
- Testing Results : Gear Selection
- Testing Results : Pulse Comparison
- Conclusion



BACKGROUND

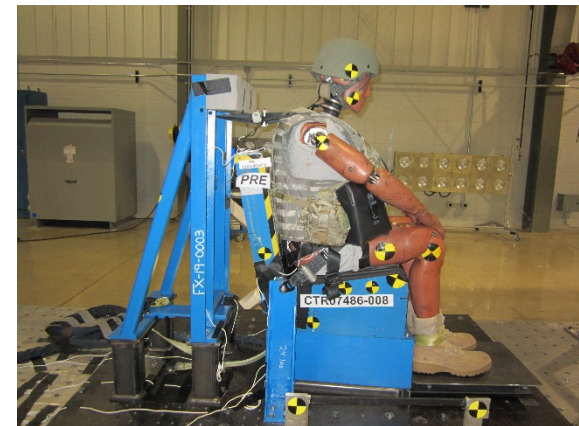


- Crash testing and validation of Military vehicles has to date not accounted for the Soldier gear burden.
- Actual loads imparted onto the occupant in a representative military vehicle crash test environment have been limited and do not reflect what an occupant would actually see in this type of an event.
- The US Army Soldier encumbered with their gear poses a challenge in restraint system design that is not typical in the automotive world.
- The weight of the gear encumbrance may have a significant effect on how the restraint system performs and protects the occupant during a frontal event.

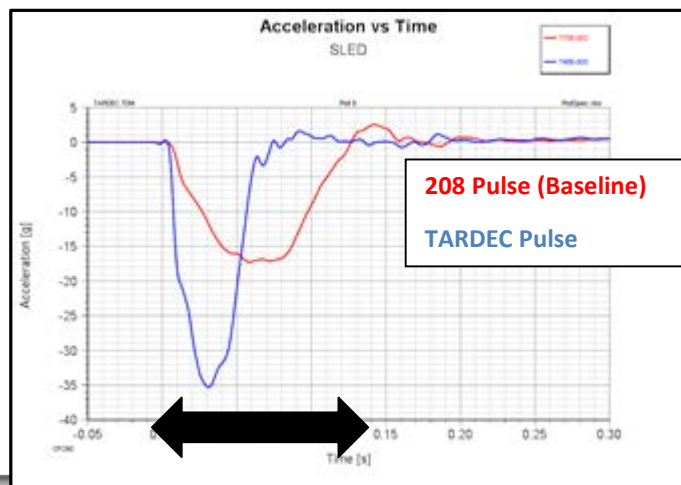
- To investigate gear and accelerative pulses as they relate to the restraints and occupant interaction.



Gear Difference

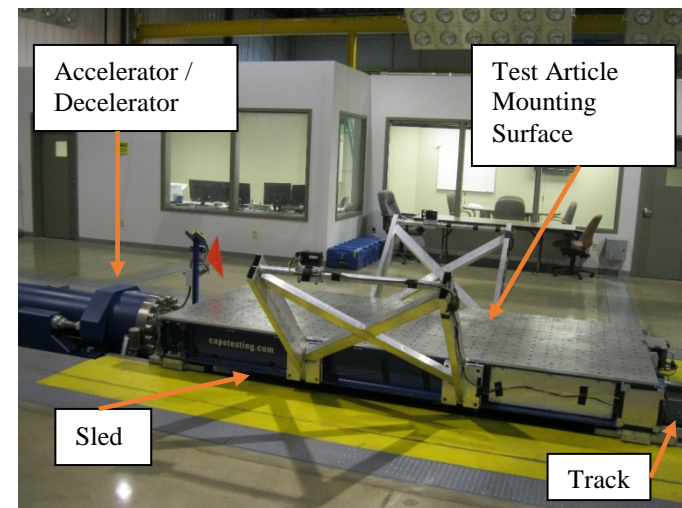
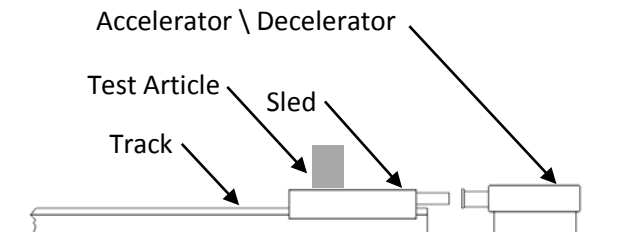


Peak
Duration
Delta

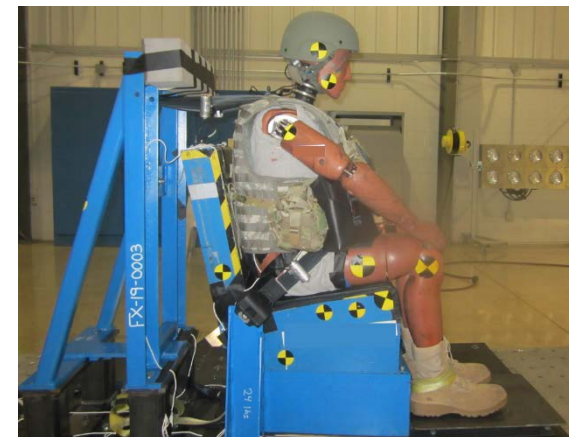
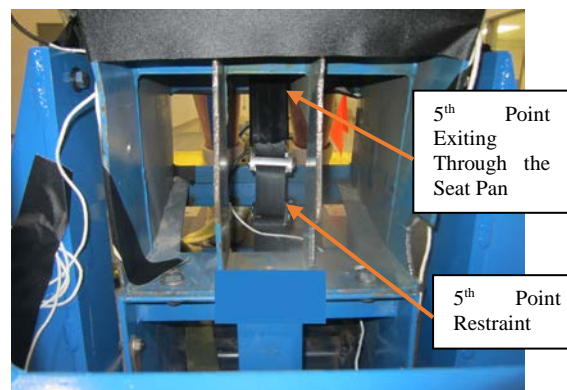
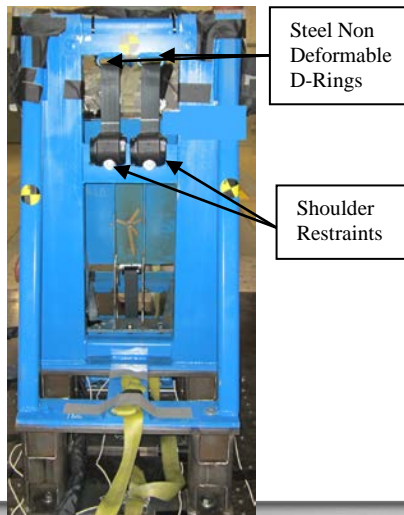


Peak
Acceleration
Delta

- The frontal crash sled test series used for this effort utilized a rigid seat mounted on a servo-hydraulic sled. The sled was propelled by an open-loop pneumatic actuator and the acceleration profile was controlled by a closed-loop 10 kHz hydraulic servo-brake.



- A modified rigid steel seat similar to the type used for ECE R16 compliance testing was used in this study in an effort to reduce test related experimental variation which may occur when using a conventional blast test seat.
- The restraint system was anchored to structure that was fixed to the sled
- All of the anchor points and areas where the seatbelt passed through the structure were non-deformable.





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ENCUMBRANCE SELECTION



- The encumbrance selected for this testing series was the SAW Gunner configuration.
- The SAW Gunner configuration adds roughly 30kg to the overall 50th percentile ATD weight.
- added weight contributes to the increase in total energy managed by the restraint





TESTING RESULTS: GEAR COMPARISON



- Initial sled test runs were conducted to determine the effects of the encumbrance on the restraint system and injury assessment values.
- The baseline test was run without gear and a second test was run with SAW Gunner encumbrance and helmet.
- Results indicate the gear load contributed to increased excursions and injury value changes on certain criterion.
- To better understand the differences in displacement, measurements were taken at the head and knee during their maximum excursion via video analysis.

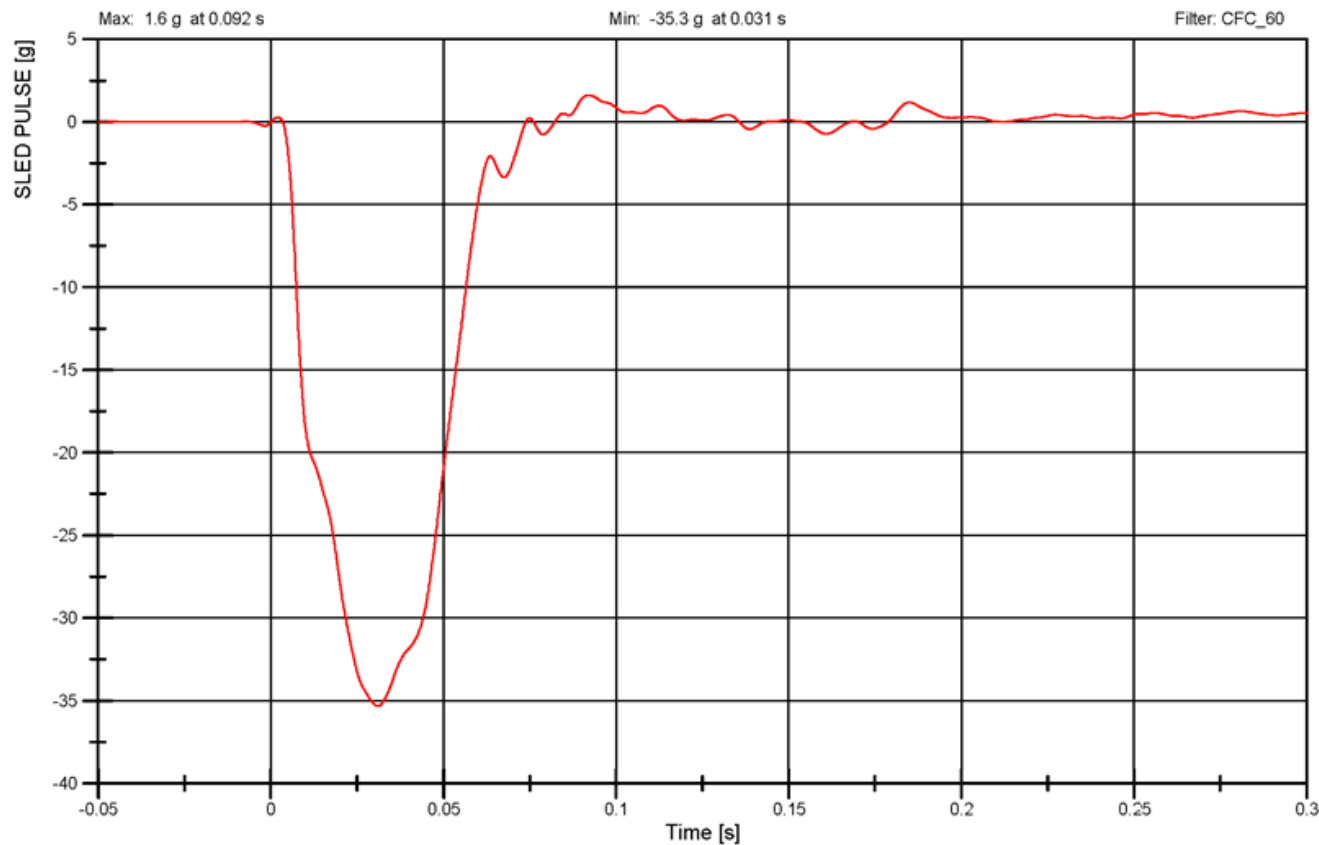


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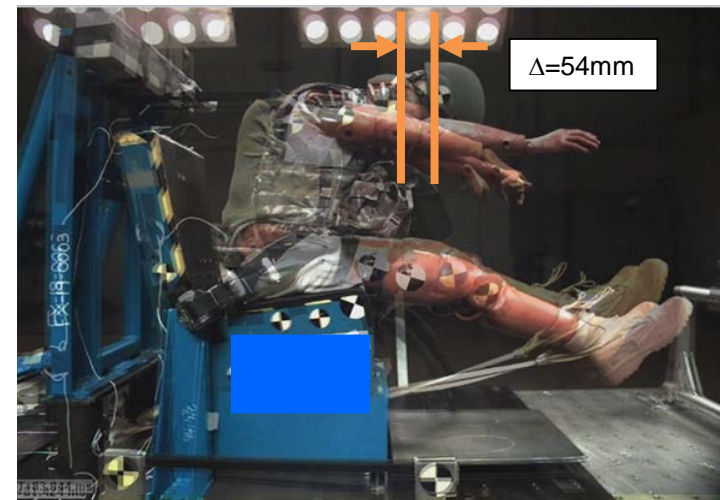
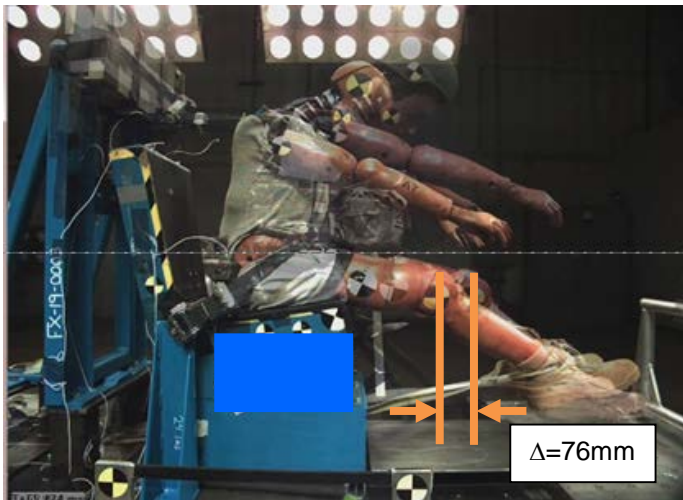
TESTING RESULTS: GEAR COMPARISON PULSE



- 35g Pulse
- 30mph Velocity



- The maximum pelvic excursion of the encumbered ATD was 76mm greater than the unencumbered ATD
- The maximum head excursion of the encumbered ATD was 54mm greater than the unencumbered ATD





TESTING RESULTS: GEAR COMPARISON INJURY AND RESTRAINT LOAD VALUES



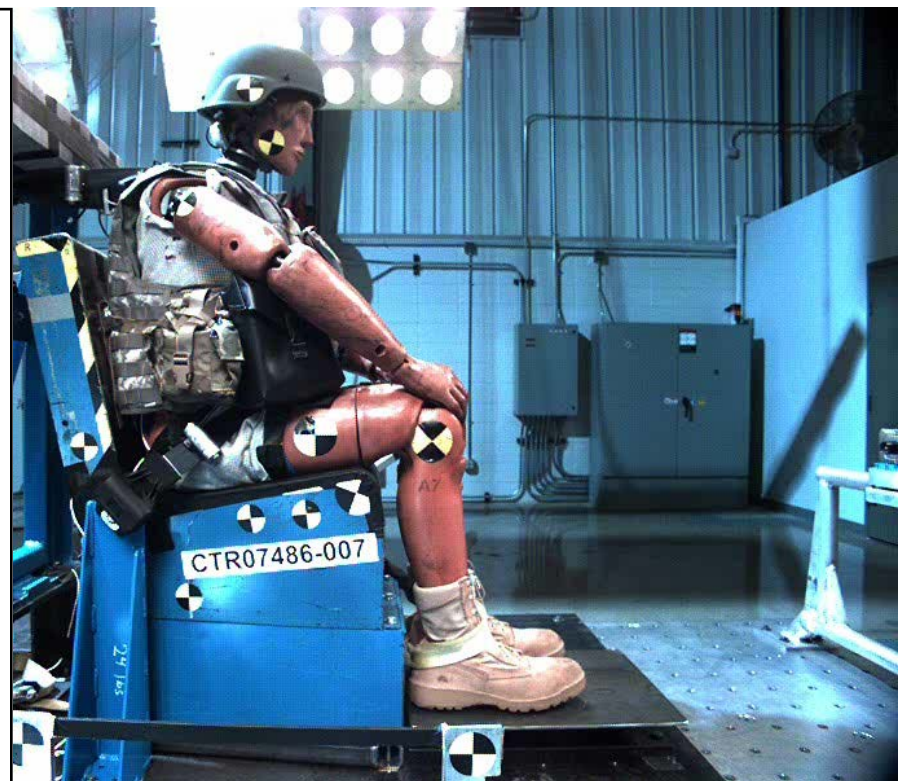
Gear Study TARDEC Pulse				
	w/o Gear (Baseline)	w/ Gear	Delta	% Change from Baseline
HIC 15	541	484	-57	-10.54%
Chest Resultant (g)	76	61	-12	-16.44%
Chest Deflect (mm)	21	66	45	214.29%
Neck Fx (N)	1483	1550	67	4.52%
Neck Fz (N)	3292	4216	924	28.07%
Neck My (N-M)	123	172	49	39.84%
Pelvis Resultant (g)	78	71	-7	-8.97%

Gear Study TARDEC Pulse				
	w/o Gear (Baseline)	w/ Gear	Delta	% Change from Baseline
Left Shoulder Load Cell (N)	9123	10588	1465	16.06%
Right Shoulder Load Cell (N)	5045	10653	5608	111.16%
Left Lap Load Cell (N)	8899	8457	-442	-4.97%
Right Lap Load Cell (N)	9137	8300	-837	-9.16%
5th Point Load Cell (N)	19764	13314	-6450	-32.64%
Total Load (N)	51968	51312	-656	1.26%



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TESTING RESULTS: GEAR COMPARISON VIDEOS





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TESTING RESULTS: PULSE COMPARISON



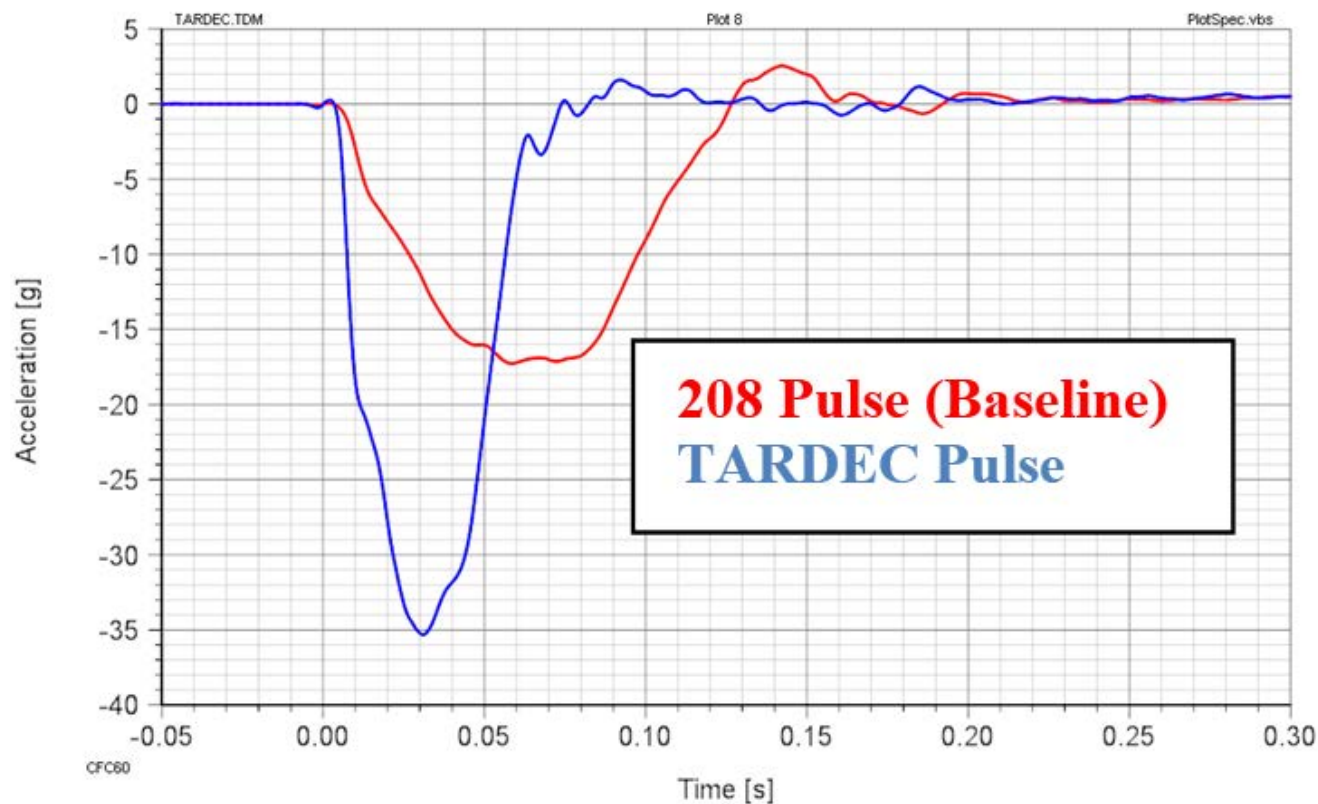
- A second series of tests were conducted to compare the difference between the TARDEC GSS developed pulse and the FMVSS 208 pulse.
- Sled tests were conducted utilizing the SAW gunner gear.
- The FMVSS 208 pulse was the baseline and the second pulse was the more aggressive TARDEC GSS pulse.



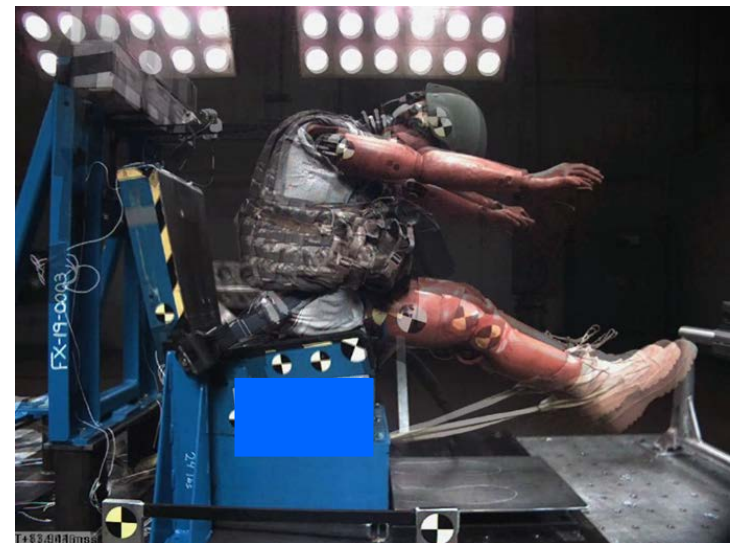
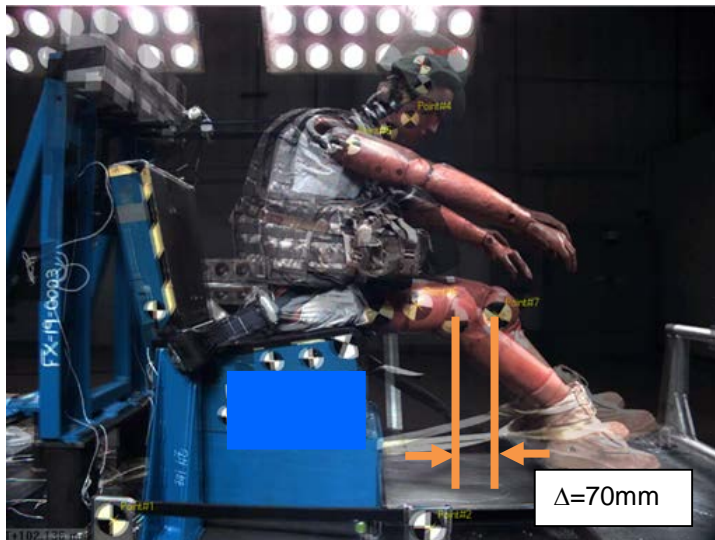
TESTING RESULTS: PULSE COMPARISON PULSES



- 35g vs 17g peak pulse
- Both are 30mph



- The maximum pelvic excursion of the dummy with the TARDEC Pulse was 70mm greater than the FMVSS Pulse.
- The maximum head excursion could not be calculated due to poor target visibility.





TESTING RESULTS: PULSE COMPARISON INJURY AND RESTRAINT LOAD VALUES



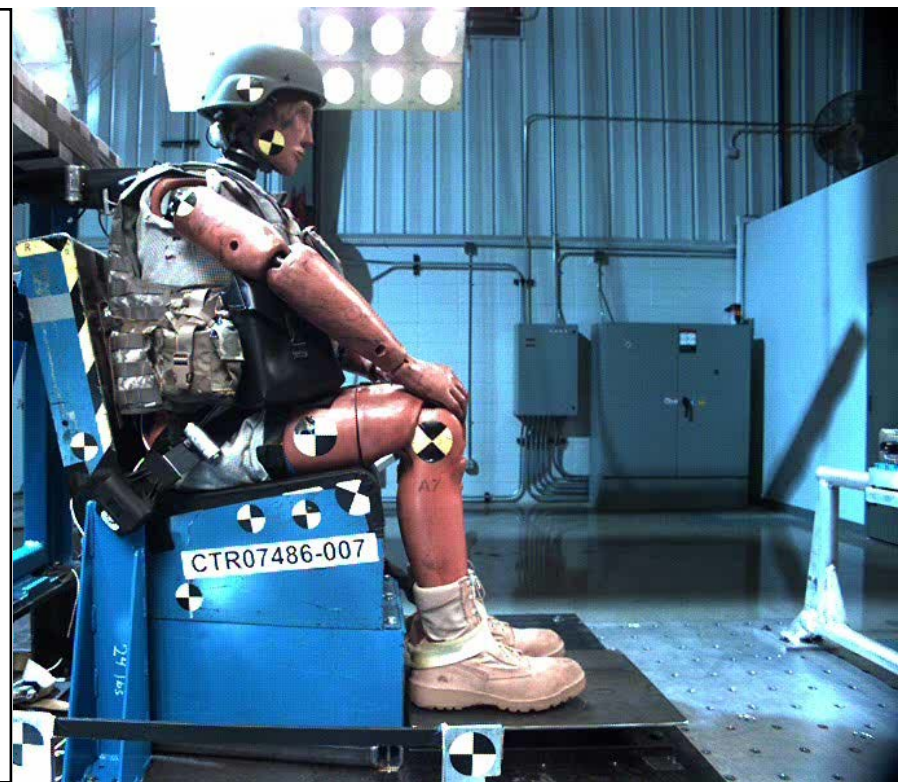
TARDEC Pulse Study				
	208 pulse (Baseline)	TARDEC Pulse	Delta	% Change from Baseline
HIC 15	188	484	296	157.45%
Chest Resultant (g)	34	61	27	79.41%
Chest Deflect (mm)	55	66	11	20.00%
Neck Fx (N)	1102	1550	448	40.65%
Neck Fz (N)	2346	4216	1870	79.71%
Neck My (N-M)	92	172	80	86.96%
Pelvis Resultant (g)	30	71	41	136.67%

TARDEC Pulse Study				
	208 Pulse (Baseline)	TARDEC Pulse	Delta	% Change from Baseline
Left Shoulder Load Cell (N)	6939	10588	3649	52.59%
Right Shoulder Load Cell (N)	6625	10653	4028	60.80%
Left Lap Load Cell (N)	4829	8457	3628	75.13%
Right Lap Load Cell (N)	4514	8300	3786	83.87%
5th Point Load Cell (N)	6245	13314	7069	113.19%
Total Load (N)	29152	51312	22160	76.02%



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TESTING RESULTS: PULSE COMPARISON VIDEOS





CONCLUSION



- Gear Comparison:
 - Can become damaged and load anomalies may exist when the restraints are routed improperly
 - Produces higher chest displacements
 - Causes the neck to extend as the head and neck rotate forward
- Pulse Comparison:
 - Pulses that are less aggressive cause timing of the injuries to shift and have lower magnitudes.
 - Do not appear to have an effect on neck and chest reactions with an encumbered occupant.
 - Restraint loads appear to increase as the crash pulse is made more aggressive